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(71) Applicant
Nippon Oil Co. Ltd.,

(Incorporated in Japan),

3-12 Nishishinbashi 1-Chome, Minato-ku, Tokyo, Japan

(72) Inventor
Shozo Tsuchiya

(74) Agent and/or Address for Service
Graham Watt & Co., Riverhead, Sevenoaks, Kent TN13 2BN

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GB A 2070019 US 4218360
EP A 0075537

(58) Field of search
C3B
C3K
C3L

(54) Photo-curable coating composition

(57) An ultraviolet-curable coating composition comprises (A) a multifunctional epoxy oligomer such as a bisphenol A derivative, (B) a finely powdered inorganic filler having its surfaces treated with a hydrolysis product of an epoxy-containing silane coupling agent such as β-glycidoxypropyl-trimethoxysilane and (C) a photo-initiator capable of inducing the reaction of epoxy groups on exposure to ultraviolet radiation. The composition cures to form a transparent or semitransparent, hard coating film having excellent abrasion resistance.

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SPECIFICATION

Photo-curable coating composition

This invention relates to a photo-curable coating composition. More particularly, it relates to a coating composition which, when applied to the surface of an article requiring excellent abrasion resistance and exposed to ultraviolet radiation for a short period of time, can form a transparent or semitransparent coating film capable of protecting the coated article. The composition can yield a coating having excellent abrasion resistance.

In recent years, the range of use of plastics articles have grown wider and wider. Especially in the fields of automobiles, electronic equipment and business machines, the use of plastics is increasing because of their advantages such as ease of fabrication or lightness in weight. One of the greatest disadvantages of plastics moldings is that their surfaces are more subject to scratching than metal or glass surfaces. Especially in the case of organic glass typified by polymethyl methacrylate (PMMA) and polycarbonate (PC), a loss of transparency caused by damage to its surface may be fatal. Thus, it is necessary to protect the surface by some means.

In order to prevent the surfaces of such plastics moldings from being damaged, a large number of compositions and methods have already been proposed. They can be broadly classified into three types.

In the first method, a thermosetting silicone resin or the like is applied to plastics articles and cross-linked by the application of heat to form a hard coating film. This cured film exhibits very high hardness and hence excellent abrasion resistance, but has the disadvantage of lacking flexibility and being brittle. Moreover, this method is also disadvantageous in that the rate of cure by the application of heat is slow, and silicone resins are expensive.

The second method involves the use of a composition comprising a prepolymer having multifunctional acryloyl groups a multifunctional or monofunctional reactive solvent, and a photo-initiator. This composition is applied to plastics articles and then exposed to ultraviolet radiation to effect the polymerization reaction of acryloyl groups and thereby form a cured film. This method is suitable for the coating of plastics articles because the reaction is completed in several seconds to several tends of seconds and the application of heat is not required. However, the coating film so formed consists of a purely organic substance and, therefore, may fail to exhibit adequate hardness and satisfactory abrasion resistance.

The third method is, so to speak, a compromise between the above-described two methods. According to this method, an inorganic material such as silica or alumina is dispersed in a prepolymer or monomer having photo-reactive acryloyl groups and the resulting composition is cured by photo-curing reaction so that the cured film will have a high hardness reflecting the nature of the inorganic filler. In this case, the surfaces of the filler are treated with an organic material for the purpose of facilitating the dispersion of the filler in the organic matrix. The prior art concerning this method includes, for example, Japanese Patent Laid-Open No. 500984/'82, Japanese Patent Laid-Open No. 500251/'83 and Japanese Patent Laid-Open No. 74369/'82. Although this method can yield a coating film having high hardness, the photo-curing reaction relies on the polymerization of acryloyl groups and, therefore, this polymerization results in a high degree of volume shrinkage and hence inadequate adhesion to the article to be coated. Moreover, this reaction is a radical reaction and, therefore, has the disadvantage that the curing rate of the surfaces is slow if the reaction is carried out in the presence of air containing oxygen.

The present invention aims, for example, to provide a photo-curable coating composition which can form a transparent or semitransparent, hard coating film having excellent abrasion resistance.

Desirably a coating composition is provided which can be rapidly cured in air by exposure to ultraviolet radiation and can yield a cured film exhibiting a low degree of volume shrinkage and good adhesion to an article to be coated.

According to the present invention, there is provided an ultraviolet-curable coating composition containing, as essential components,

(A) 100 parts by weight of a multifunctional epoxy oligomer,

(B) 5 to 100 parts by weight of a finely powdered inorganic filler having its surfaces treated with a hydrolysis product of a compound of the general formula

$$(RO)_{3-n}SiR^1R^2_n \qquad [I]$$

where n is equal to 0 or 1, R is a methyl, ethyl or propyl group, R^1 is an epoxy-containing organic radical of 3 to 20 carbon atoms selected from epoxyalkyl, epoxycycloalkyl, epoxycycloalkylalkyl, glycidoxy and glycidyl ether groups, and R^2 is an organic radical of 1 to 20 carbon atoms selected from alkyl, cycloalkyl, aminoalkyl, alkylamino, alkoxy, alkoxyalkyl, epoxyalkyl, epoxycycloalkyl, alkenyl, glycidoxy, methacryloxyalkyl and γ-mercaptopropyl groups; and

(C) 0.1 to 10 parts by weight of a photo-initiator capable of inducing the reaction of epoxy groups on exposure to ultraviolet radiation.

Specifically, the ultraviolet-curable coating composition of the present invention is obtained by using an epoxy resin or an epoxy-containing monomer as an organic matrix, dispersing in the organic matrix an inorganic filler (such as silica or alumina) which has been grafted by surface treatment with an

epoxy-containing silane coupling agent and hence has epoxy groups in its surfaces, and adding thereto a photo-initiator comprising a compound which itself undergoes a reaction (such as decomposition) upon exposure to ultraviolet radiation and forms a certain acid capable of inducing the ring opening of epoxy groups.

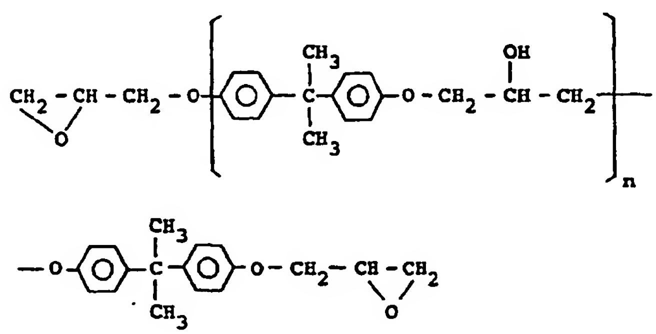
When this particular composition is exposed to ultraviolet radiation, the photo-initiator decomposes to form an acid which, in turn, induces the ring opening reaction of the epoxy compound and thereby brings about a cure of the composition. During this process, the functional groups present in the surfaces of the silica or alumina treated with an epoxy-containing silane coupling agent also undergo the reaction, so that the inorganic filler is incorporated in the matrix to form a hard coating film. Moreover, since the curing reaction is the ring opening reaction of epoxy groups, the degree of volume shrinkage is low and the formation of hydroxyl groups results from the ring opening reaction. For these reasons, a coating film formed of this cured composition has good adhesion to the article to be coated. Furthermore, since epoxy resins having different properties are being industrially produced and are available for use as the organic matrix, coating films having better flexibility can also be obtained by using properly selected epoxy resins.

As described above, the present invention provides a coating composition which can be cured by exposure to ultraviolet radiation to form a coating film having excellent abrasion resistance and improved adhesion to the article to be coated.

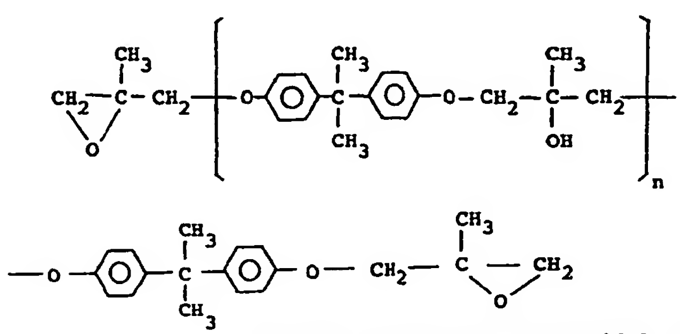
The invention will now be described in more detail in the following detailed description, which is given by way of non-limiting example of the invention.

The multifunctional epoxy oligomer used in the present invention can be any of a wide variety of what is generally called epoxy resins more specifically, various types of epoxy resins represented by the following formulas may be used in the present invention:

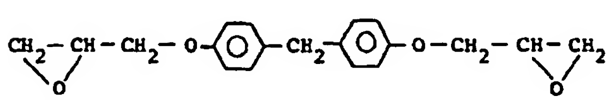
Glycidyl ether type



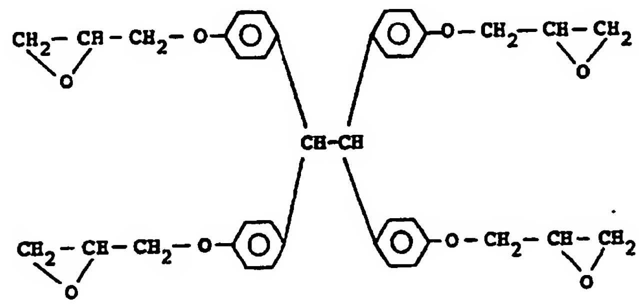
Bisphenol A diglycidyl ether



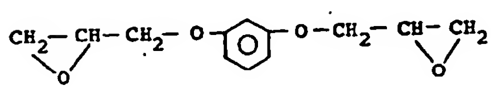
Bisphenol A di-β-methylglycidyl ether



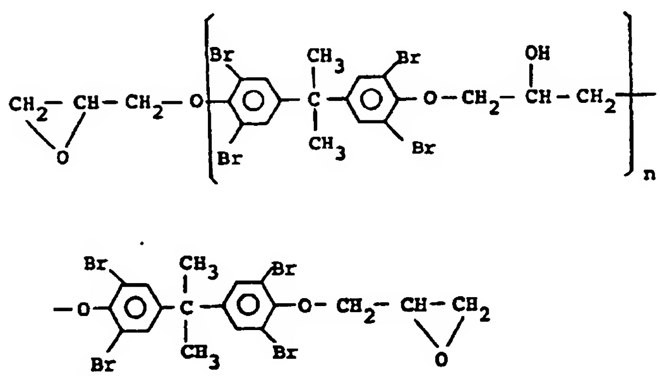
Bisphenol F diglycidyl ether



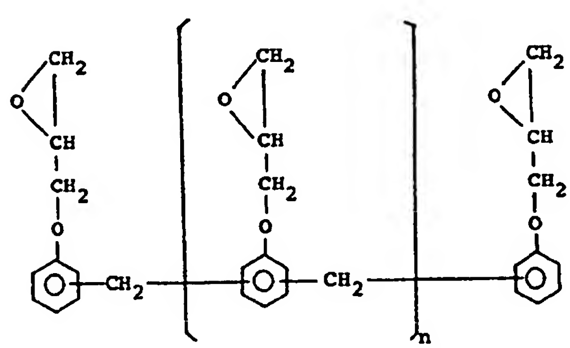
Tetrahydroxyphenylethane tetraglycidyl ether



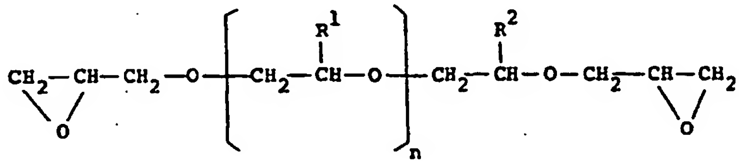
Resorcinol diglycidyl ether



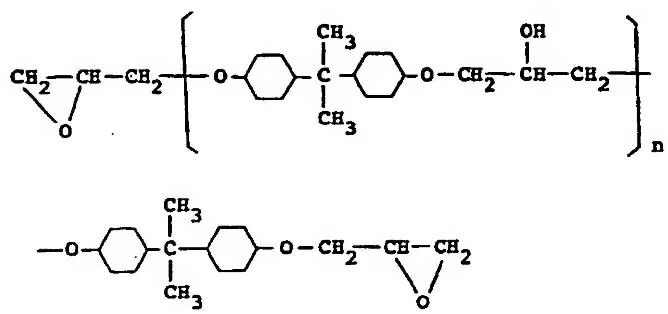
Brominated bisphenol A diglycidyl ether
(the Br atoms may be replaced by Cl atoms)



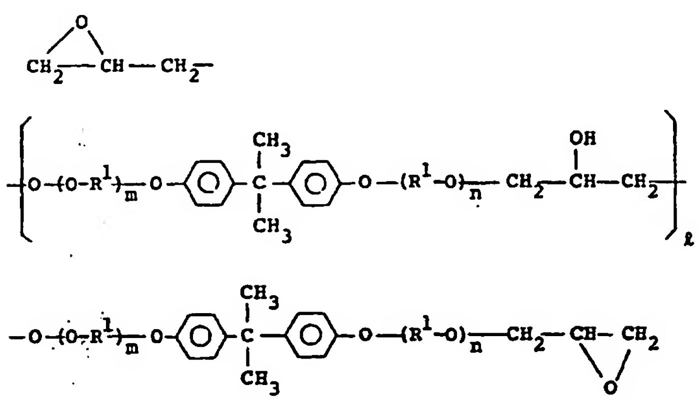
Novolak glycidyl ether



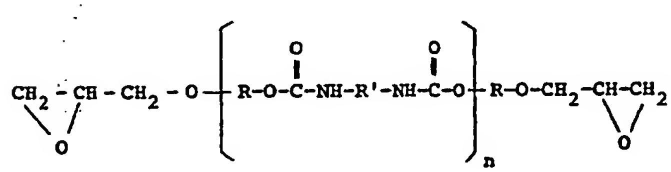
Polyalkylene glycol diglycidyl ether



Hydrogenated bisphenol A glycidyl ether



Diglycidyl ether of an adduct of bisphenol A
with an alkylene oxide

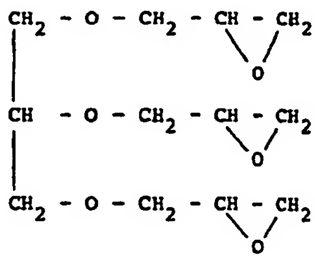


where

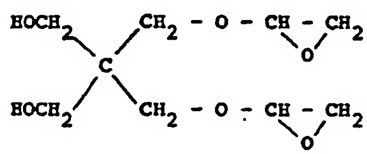
$$R = -(CH_2)_n- \;,\; -(CH_2-CH_2-O)_n- \;\text{or}\; -\left(\begin{matrix} R_1 & & R_3 & & \\ | & & | & & \\ C & - & C & - & O \\ | & & | & & \\ R_2 & & R_4 & & \end{matrix}\right)_n-$$

$R' = -\!(C_6H_4)\!-,\ -\!(CH_2)_n\!-$ or $-\!(C_6H_4-CH_2-C_6H_4)\!-$

Epoxyurethane resin

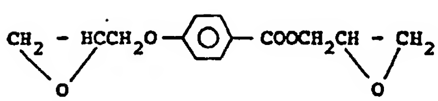


Glycerol triglycidyl ether



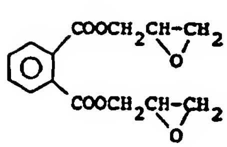
Pentaerythritol diglycidyl ether

Glycidyl ether-ester type

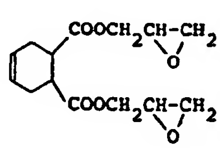


p-Hydroxybenzoic acid glycidyl ether-ester

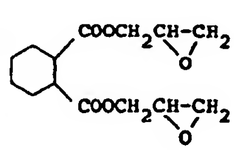
Glycidyl ester type



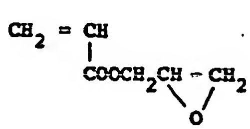
Diglycidyl phthalate



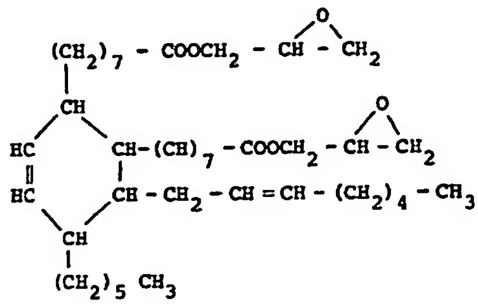
Diglycidyl tetra-hydrophthalate



Diglycidyl hexa-hydrophthalate

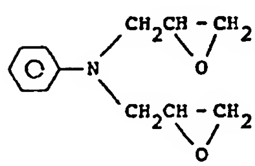


Glycidyl acrylate

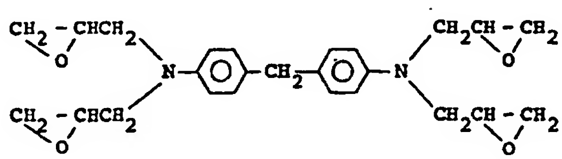


Diglycidyl ester of a dimer acid

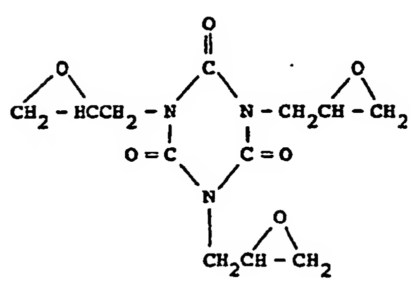
Glycidylamine type



Glycidylaniline

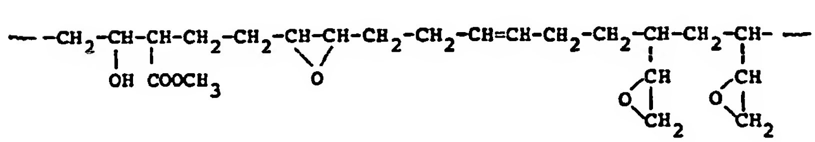


Tetraglycidylaminodiphenylmethane

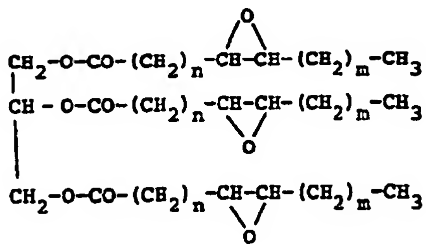


Triglycidylisocyanurate

Linear aliphatic epoxy resins

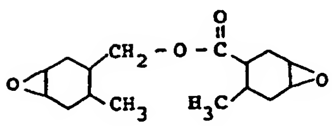


Epoxidized polybutadiene

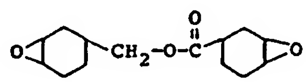


Epoxidized soybean oil

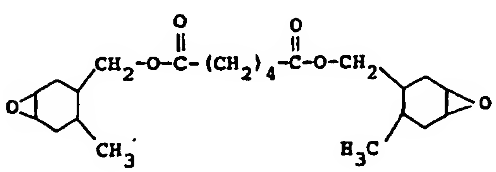
Alicyclic epoxy resins



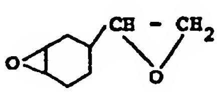
3,4-Epoxy-6-methylcyclohexylmethyl (3,4-epoxy-6-methylcyclohexane)-carboxylate



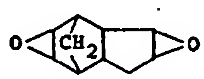
3,4-Epoxycyclohexylmethyl (3,4-epoxy-cyclohexane)carboxylate



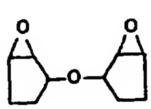
Bis(3,4-epoxy-6-methylcyclohexylmethyl) adipate



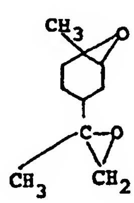
Vinylcyclohexene diepoxide



Dicyclopentadiene oxide



Bis(2,3-epoxycyclopentyl) ether



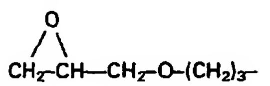
Limonene dioxide

In the above formulas, R^1, R^2, R^3 and R^4 independently represent hydrogen atoms or alkyl groups having 1 to 6 carbon atoms, and ℓ, m and n independently represent whole numbers of 0 to 20.

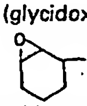
The finely powdered inorganic filler having its surfaces treated with an organosilicon compound [component (B)], which is used in the coating composition of the present invention, is obtained by treating the surfaces of finely powdered silica, alumina or other inorganic filler with what is generally called a silane coupling agent. Although typical examples of the finely powdered inorganic filler are silica and alumina, other inorganic fillers such as clay, talc, mica, asbestos, calcium silicate, glass powder, titania and magnesia may also be used. These inorganic fillers should preferably have as small a particle diameter as possible, and it is usually preferable to use an inorganic filler having an average particle diameter of 0.001 to 1 μm and more preferably 0.007 to 0.020 μm. Specifically, useful silica products include AEROSIL-380, -300, -200, -R972 (manufactured by Degussa A.G., West Germany) and Hi-SIL-233 and -215 (manufactured by PPG Industries, Inc., U.S.A.), and useful alumina products include ALON (manufactured by Alcan Co., Canada).

The organosilicon compound of the formula $(RO)_{3-n}SiR^1R^2_n$, which is hydrolyzed and used to treat the surfaces of the inorganic filler, should contain an epoxy group in R^1.

The groups represented by R^1 include, for example, glycidyl, glycidoxy,



(glycidoxypropyl), epoxycyclohexyl,

 $(CH_2)_2$-(2,3-epoxycyclohexylethyl. R^2 may or may not contain an epoxy group and is selected from a wide variety of groups including, for example, alkyl, cycloalkyl, aminoalkyl, alkylamino, alkoxy, alkoxyalkyl, epoxyalkyl, epoxycycloalkyl, alkenyl, glycidoxy, methacryloxyalkyl and γ-mercaptopropyl. R is selected from lower alkyl groups such as methyl, ethyl and propyl groups.

Specific examples of the organosilicon compound of formula [I] include:
γ-glycidoxypropyl-trimethoxysilane,
β-(3,4-epoxycyclohexyl)ethyl-trimethoxysilane,
γ-glycidoxypropyl-ethyl-dimethoxysilane,
β-(3,4-epoxycyclohexyl)ethyl-n-propyl-dimethoxysilane,
di(γ-glycidoxypropyl)-dimethoxysilane,
glycidyl-trimethoxysilane,
3,4-epoxycyclohexyl-trimethoxysilane and
3,4-epoxycyclohexyl-ethyl-dimethoxysilane.

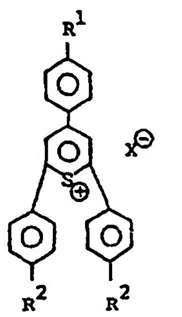
In treating the surfaces of the inorganic filler, the organisilicon compound [I] used for this purpose is dispersed in water and hydrolyzed to convert its -OR groups into -OH groups. Specifically, the organosilicon compound [I] is hydrolyzed according to the following equation.

$$\underset{[I]}{(RO)_{3-n}SiR^1R^2_n} \longrightarrow \underset{[I']}{(HO)_{3-n}SiR^1R^2_n}$$

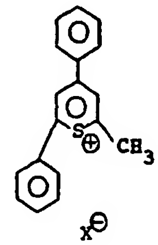
Then, the finely powdered inorganic filler is dispersed in this aqueous solution. The resulting dispersion is vigorously stirred for a period of time ranging from 15 minutes to 2 hours until the reaction of the hydrolysis product [I'] with the surfaces of the inorganic filler is completed. Thereafter, the water is evaporated to obtain a surface-treated inorganic filler useful as component (B). For the purpose of surface treatment, it is preferable to use the organosilicon compound [I] in an amount of 5 to 50 parts by weight per 100 parts by weight of the inorganic filler. If the amount of organosilicon compound used is less than 5 parts by weight, the surface treatment may fail to produce a satisfactory effect, and if it is greater than 50 parts by weight, some of the surface-treating compound will remain unreacted and tend to reduce the abrasion resistance of the resulting composition.

The photo-initiator used as component (C) for effecting the reaction of epoxy groups is a compound which, on exposure to ultraviolet radiation, decomposes or reacts to form a certain acid capable of inducing the ring opening of epoxy groups. Specifically, such compounds are salts containing onium cations. Typical examples thereof include aryldiazonium salts [A] of the formula $ArN_2^+X^-$, diaryliodonium salts [B] of the formula $Ar_2I^+X^-$, triarylsulfonium salts [C] of the formula $Ar_3S^+X^-$ and dialkylarylsulfonium salts [D] of the formula $ArS^+R_2X^-$. In these formulas, X^- is BF_4^-, PF_6^-, AsF_6 or SbF_6^- and R is an alkyl group.

In addition to the foregoing salts [A] to [D], thiopyrylium salts of the following formulas can also be used.



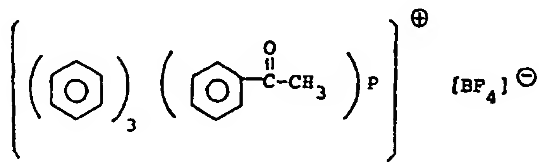
2,4,6-Triarylthiopyrylium salt

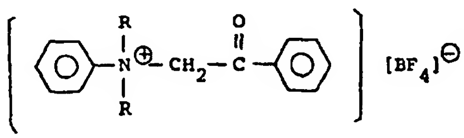


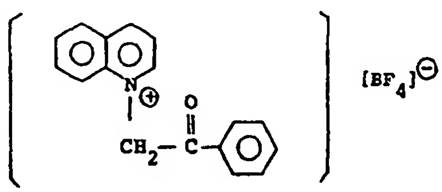
2-Methyl-4,6-diphenylthiopyrylium salt

In the above formulas, R^1 is H-, CH_3O, NO_2- or Cl-, R^2 is H-, CH_3- or CH_3O-, and X is BF_4 or PF_6.

Furthermore, onium salts of the following formulas can also be used.







In the above formulas, R is an alkyl group having 1 to 4 carbon atoms.

The coating composition of the present invention is obtained by mixing the aforesaid three components (A), (B) and (C) and dispersing or dissolving them in one another. In mixing these components, the surface-treated inorganic filler in finely powdered form [component (B)] should be added in an amount of 5 to 100 parts by weight per 100 parts by weight of the epoxy oligomer [component (A)]. If the amount of the surface-treated inorganic filler is less than 5 parts by weight, the addition of the filler may fail to produce its desired effect, while if it is greater than 100 parts by weight, the transparency of the composition will be lost and the viscosity of the composition will become unduly high. The photo-initiator [component (C)] should be added in an amount of 0.1 to 10 parts by weight per 100 parts by weight of component (A), the preferred range being from 1.0 to 5.0 parts by weight. If the amount of the photo-initiator is less than 0.1 part by weight, the reaction will become slow, while if it is greater than 10 parts by weight, the photo-initiator component may deteriorate the properties of the coating film.

The composition of the present invention is applied to an article to be coated and then cured by exposure to ultraviolet radiation to form a coating film. In order to reduce the viscosity of the composition and thereby facilitate its application to an article to be coated, any of the various conventionally-known diluents for use with epoxy resins may be added thereto. Where epoxy-containing monomers (such as cyclohexene oxide and butene oxide) are used as diluents, they are incorporated in the cured film as a result of the photo-reaction. However, where ordinary non-reactive solvents (such as toluene, methyl ethyl ketone and ethyl acetate) are used, they must be distilled off at elevated temperature or evaporated at room temperature prior to the photo-curing step.

Although the coating composition of the present invention consists basically of components (A), (B) and (C),

it may further contain leveling agents for improving the smoothness of the coating surface, various types of stabilizers, and other additives.

The present invention is more specifically explained with reference to the following examples.

Preparation Example

200 g of β-glycidoxypropyl-trimethoxysilane was stirred with and dispersed in 4,000 g of water adjusted to pH 4.0. This dispersion became clear on standing for 1 hour. Then, 800 g of finely powdered silica (AEROSIL-380, average particle diameter: 0.007 μm) was added thereto and this mixture was stirred for 20 minutes in a homogenizer (manufactured by Niro Atomizer A/A, Denmark) fitted with a high-speed stirrer. The resulting dispersion was dehydrated and dried with a spray dryer (manufactured by Tokushu Kika Kogyo K.K.) to obtain a white powder of treated silica (hereinafter referred to briefly as B-1).

Example 1

100 g of Epicoat 828 [component (A); manufactured by Shell Oil Co.), which is a liquid epoxy resin derived from bisphenol A, was mixed with 25 g of the treated silica B-1 [component (B)] obtained in the Preparation Example, and this mixture was ball-milled for 20 hours to form a dispersion. Then, 2 g of diphenyldiazonium tetrafluoroborate [component (C)] was dissolved therein as a photo-initiator to obtain a coating composition (Composition 1).

Using a spin coater (at 4000 rpm), this composition was applied to a PMMA resin plate (manufactured by Kyowa Gas Chemical Co.) to a thickness of 12 μm and then cured by irradiating it for 10 seconds with a 160 W/cm high pressure mercury vapor lamp (manufactured by Ushio Electric Co.) located at a distance of 15 cm. The coating film formed on the resin plate was transparent (with a haze of 0.1% as measured with a haze meter) and its adhesion was as good as 100/100 when evaluated by a tape test.

Moreover, the coated resin plate was subjected to a Taber abrasion test (testing conditions: CS10, 500 g × 2, 100 rpm, as prescribed by ASTM D-1044).

After the test, its haze was measured with a haze meter (manufactured by Suga Testing Machine Co.) and found to be 0.8%. This indicates that the coating film showed no significant decrease in transparency and, therefore, had good abrasion resistance.

Examples 2 to 4 and comparative example 1

Coating compositions were prepared in the same manner as described in Example 1, except that the types and amounts of components (A), (B) and (C) were altered as shown in Table 1, each of these compositions was applied and cured to form a coating film. The coating films so formed were subjected to an adhesion test and a Taber abrasion test. The results thus obtained are shown in Table 2.

TABLE 1

	Component (A)	Component (B)	Component (C)
Example 2	Epicoat 828, 100 g	B-1, 25 g	Triphenylsulfonium tetrafluoroborate, 3 g
Example 3	Epicoat 828, 100 g	B-1, 20 g	Dimethyl-4-hydroxy-phenylsulfonium salt, 2 g
Example 4	Resorcinol diglycidyl ether, 50 g Novolak glycidyl ether, 50 g	B-1, 20 g	Diphenyliodoium salt, 2 g
Comparative Example 1	Epicoat 828, 100 g	-	Diphenyldiazonium tetrafluoroborate, 3 g

TABLE 2

	Adhesion (tape test)	Haze (%) of coating film before and after Taber abrasion test	
		Before	After
Example 2	100/100	0.2	1.0
Example 3	100/100	0.2	1.2
Example 4	100/100	0.1	1.3
Comparative Example 1	100/100	0.1	15.0

It can be seen that the coating films obtained in Example 2 to 4 had excellent abrasion resistance, while the coating film of Comparative Example 1 not containing component (C) had inadequate abrasion resistance.

Comparative example 2

3 g of benzoin methyl ether, a radical initiation type photo-initiator, was dissolved in a mixture composed of 50 g of trimethylolpropane triacrylate and 50 g of pentaerythritol acrylate, both having a photo-reactive acryloyl group. Using a spin coater, this composition was applied to a PMMA resin plate to a thickness of 15 μm and then cured by exposure to ultraviolet radiation under the same conditions as described in Example 1. The coating film so formed was transparent (with a haze of 0.1%). When the coated resin plate was subjected to a Taber abrasion test under the same conditions as described in Example 1, the haze of the coating film was found to be 17%, indicating its inadequate abrasion resistance. Moreover, it is believed that the prior art photo-curable composition, which is cured by the polymerization reaction of acryloyl groups, will exhibit a high degree of volume shrinkage and hence a distortion of the cured film, resulting in poor adhesion.

Comparative example 3

A coating composition (Composition 1') was prepared according to the same formulation as described in Example 1, except that untreated silica (AEROSIL-380) was used as component (B) in place of the treated silica (B-1). Composition 1' was entirely opaque. Moreover, it thickened and became thixotropic during preparation and lost its fluidity, so that it could not be used for coating purposes. Thus, it was found difficult to disperse untreated silica uniformly in a matrix and thereby obtain a composition having good flow properties.

Example 5

The procedure of Example 1 was repeated except that component (B) was prepared by using β-(3,4–epoxycyclohexyl)ethyl-trimethoxysilane in place of the β-glycidoxypropyl-trimethoxysilane used for the preparation of B-1. The results thus obtained were as follows:

Transparency (haze meter):	0.1%
Adhesion (tape test):	100/100
Haze after Taber abrasion test:	0.7%

Example 6

The procedure of Example 1 was repeated except that component (B) was prepared by using finely powdered alumina (ALON; manufactured by Alcan Co., Canada, average particle diameter: 0.020 μm) in place of the finely powdered silica (AEROSIL-380) used for the preparation of B-1, and the amount of component (B) present in the coating composition was changed from 25 g to 16 g. The results thus obtained were as follows:

Transparency (haze meter):	25.8%
Adhesion (tape test):	100/100
Haze after Taber abrasion test:	25.9%

CLAIMS

1. An ultraviolet-curable coating composition containing, as essential components,
(A) 100 parts by weight of a multifunctional epoxy oligomer,
(B) 5 to 100 parts by weight of a finely powdered inorganic filler having its surfaces treated with a hydrolysis product of a compound of the general formula

$$(RO)_{3-n}SiR^1R^2_n \quad (I)$$

where n is equal to 0 or 1, R is a methyl, ethyl or propyl group, R^1 is an epoxy-containing organic radical of 3 to 20 carbon atoms selected from epoxyalkyl, epoxycycloalkyl, epoxycycloalkylalkyl, glycidoxy and glycidyl other groups, and R^2 is an organic radical of 1 to 20 carbon atoms selected from alkyl, cycloalkyl, aminoalkyl, alkylamino, alkoxy, alkoxyalkyl, epoxyalkyl, epoxycycloalkyl, alkenyl, glycidoxy, methacryloxyalkyl and γ-mercaptopropyl groups; and

(C) 0.1 to 10 parts by weight of a photo-initiator capable of inducing the reaction of epoxy groups on exposure to ultraviolet radiation.

2. The composition according to claim 1, wherein the surface-treated inorganic filler [component (B)] is prepared by treating 100 parts by weight of an inorganic filler with a hydrolysis product obtained from 5 to 50 parts by weight of a compound of the above formula [I].

3. The composition according to claim 1 or claim 2, wherein the inorganic filler constituting the surface-treated inorganic filler [component (B)] comprises one or more materials selected from the group consisting of silica, alumina, clay, talc, mica, asbestos, calcium silicate, glass, titania and magnesia.

4. The composition according to claim 1, 2 or 3 wherein the surface-treated inorganic filler [component(B)] has an average particle diameter of 0.001 to 1 μm.

5. The composition according to claim 1, 2, 3 or 4, which further contains a diluent for epoxy resins.

6. The composition according to any of claims 1 to 5, which contains further additives including stabilizers and/or leveling agents.

7. The composition according to any of claims 1 to 6, wherein the epoxy oligomer is selected from glycidyl ether resins, bisphenol A diglycidyl ether, bisphenol A di-β methylglycidyl ether, bisphenol F diglycidyl ether, tetrahydrophenylethane tetraglycidyl ether, resorcinol diglycidyl ether, brominated or chlorinated bisphenol A diglycidyl ether, novolak glycidyl ether, polyalkylene glycol diglycidyl ether, hydrogenated bisphenol A glycidyl ether, diglycidyl ether of an adduct of bisphenol A with an alkylene oxide, epoxyurethane resins, glycerol triglycidyl ether, pentaerythritol diglycidyl ether, p-hydroxybenzoic acid glycidyl ether-ester, diglycidyl phthalate, tetrahydrophthalate or hexahydrophthalate, glycidyl acrylate, diglycidyl esters of dimer acids, glycidylaniline, tetraglycidylaminodiphenyl-methane, triglycidylisocyanurate, linea aliphatic epoxy resins, epoxidised polybutadienes, epoxidised soybean oil, 3,4-epoxy-6-methylcyclohexamethyl (3,4-epoxy-6-methylcylohexane) carbyoxylate, 3,4-epoxycyclohexylmethyl (3,4-expoxycyclohexane) carboxylate, bis(3,4-epoxy-6-methylcyclohexylmethyl) adipate, vinylcyclohexene diepoxide, dicyclopertadiene oxide, bis(2,3-epoxycyclopentyl) ether and limonene dioxide.

8. The composition according to any of claims 1 to 7, wherein the compound represented by the general formula $(RO)_{3-n}SiR^1R^2_n$ is selected from α-glycidoxypropoyltrimethoxysilane, β-(3,4-epoxycyclohexyl)ethyl-trimethoxysilane, α-glycidoxypropyl-ether-dimethoxysilane, β-(3,4-epoxycyclohexyl)ether-n-propyl-dimethoxysilane, di(α-glycidoxypropyl)-dimethoxysilane, glycidyl-trimethoxysilane, 3,3-epoxycyclohexyl-trimethoxysilane and 3,4-epoxycyclohexyl-ethyl-dimethoxysilane.

9. The composition according to any of claims 1 to 8, wherein the photoinitiator is selected from aryldiazonium salts, diaryliodonium salts, triarysulfonium salts, dialkylarylsulfonium salts, thiopyrylium salts (wherein the cation is BF_4^-, PF_6^-, AsF_6^- or SbF_6^-) and onium salts (wherein the cation is BF_4^-).

10. The composition according to claim 1 and according to any of Examples 1 to 6.

11. An ultraviolet-curable coating composition according to claim 1 and substantially as herein described.

12. A plastics article having a cured coating thereon produced from the composition claimed in any of claims 1 to 11.

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